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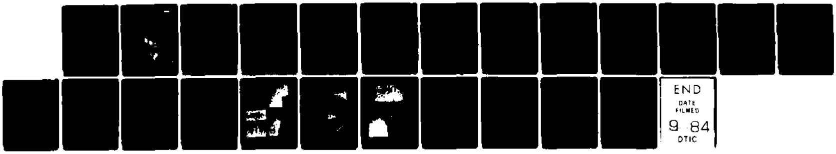

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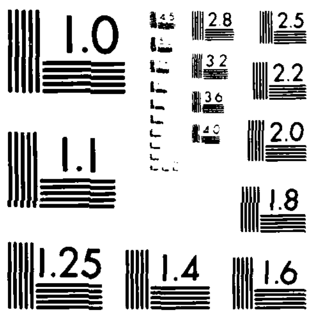

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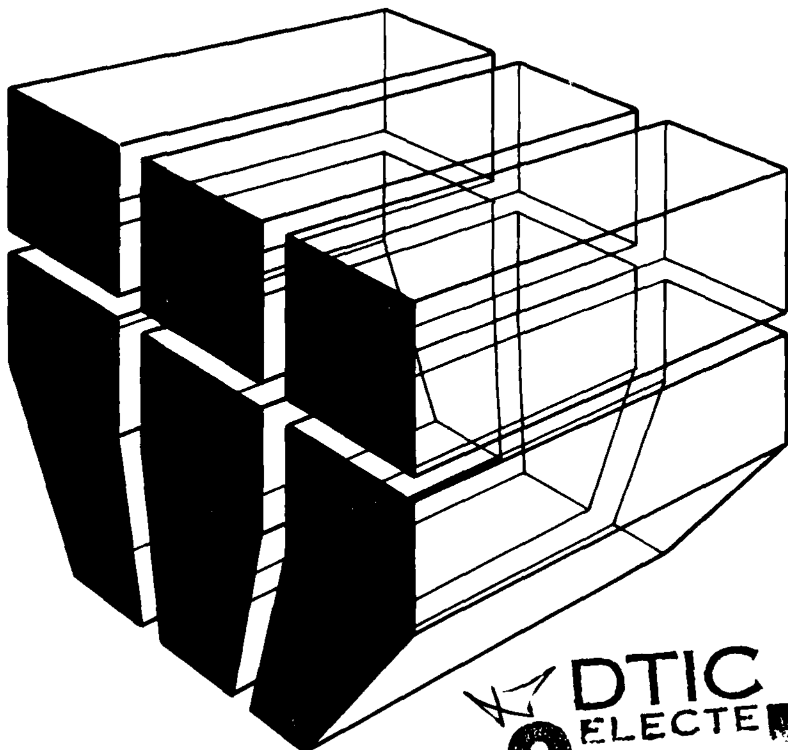
Technical Report M-351
July 1984

EVALUATION OF THE PAVEMENT CONDITION INDEX FOR USE ON POROUS FRICTION SURFACES

AD-A144 521

by
Starr D. Kohn
Mohamed Y. Shahin



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This report documents the results of a field study conducted to evaluate the use of the Pavement Condition Index (PCI) on porous friction surfaces (PFS). Pavements at seven installations using PFS were studied. Results showed that the major problems on this type of surface were: (1) deterioration of underlying asphalt concrete material due to stripping of the asphalt binder, (2) delamination due to loss of bond between the PFS and underlying layer and (3) raveling/weathering due primarily to jet blast.

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Based on the findings of this study, several modifications were recommended for incorporation into current procedures for evaluating and managing PFS pavements:

(1) Modify severity-level definitions for longitudinal/transverse cracks and for raveling/weathering;

(2) Rate low severity dense-graded patches as medium-severity;

(3) Use a surface treatment of asphaltic material if permeability loss is more than half the original;

(4) Develop a nondestructive test to locate areas of delamination;

(5) Modify the PCI of older PFS pavements carefully to document when failures occur;

(6) Collect all available PCI and construction date information for PFS pavement and use it to develop a PCI Time Chart.

FOREWORD

This study was conducted for the Air Force Engineering and Services Center (AFESC), Tyndall Air Force Base, FL, under Project Order No. F-83-37 dated 21 March 1983 by the Engineering and Materials Division (EM), U.S. Army Construction Engineering Research Laboratory (USA-CERL).

Part of the work was performed by the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, under IAO CIA083-132, dated 1 August 1983. Also working on the project were the following U.S. Air Force pavement engineers: Mr. Carl Borgwald, Headquarters, Air Force Logistic Command (HQ AFLC), Mr. Roy Almendarez, Headquarters, Air Training Command (HQ ATC), and Mr. Ellis Rustand, Headquarters, Air Force Europe (HQ USAFE). The significant contribution of the U.S. Air Force Engineers is greatly appreciated.

The WES Principal Investigator was Mr. S. D. Kohn, and the USA-CERL Principal Investigator was Dr. M. Y. Shahin. Mr. Jim Greene was the AFESC Technical Monitor.

COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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EVALUATION OF THE PAVEMENT CONDITION INDEX FOR USE ON POROUS FRICTION SURFACES

1 INTRODUCTION

Background

As part of its airfield pavement evaluation program, the U.S. Air Force (USAF) uses a visual condition survey method. The method currently required by Air Force Regulation 93-5[1] is the Pavement Condition Index (PCI) procedure developed by the U.S. Army Construction Engineering Research Laboratory (USA-CERL).[2]

The PCI is a numerical indicator of the pavement's structural integrity and surface operational condition; the index ranges from 0 to 100, with 100 indicating excellent condition. The index is a function of the type, quantity, and severity of observable distress in the pavement surface. Figure 1 summarizes the steps for calculating the PCI for a given pavement feature.

The procedure for calculating the PCI was originally developed for portland cement concrete and for asphalt- or tar-surfaced pavements. After several years of research and practical use at Air Force bases, the PCI has proved to be a meaningful index of pavement condition. However, many U.S. Air Force Europe (USAFE) installations are using an open-graded asphalt concrete mixture which results in porous friction surfaces (PFS). The mix, which is designed to be permeable, allows water to seep through the pore structure, thus increasing the skid resistance and reducing hydroplaning potential. These surfaces are not load-carrying layers and are normally placed at thicknesses in the range of 5/8 to 7/8 in.* After performing a PCI survey of these pavements, the USAFE command pavement engineer noted that the calculated PCI appeared to be higher than would be expected from a group of experienced engineers. Therefore, Headquarters, Air Force Engineering Services Center (HQAFESC) requested that the applicability of the PCI for use on porous friction surfaces be evaluated.

Purpose

The purpose of this report is to document the findings of a field study conducted to evaluate the use of PCI on porous friction surfaces and to recommend modifications to current pavement evaluation procedures based on these findings.

Approach

Field surveys were conducted at seven installations using PFS pavements. Samples from the pavements were rated by pavement engineers first using standard methods, and then visually using the PCI method. The data collected were summarized and evaluated. Recommendations for modifying the PCI method for use on PFS pavements were based on the results of the evaluations.

2 FIELD STUDY

The field surveys were performed at seven installations having PFS pavements: two in the United States and five in Germany. The bases in the United States were Hill AFB, UT, and Tyndall AFB, FL; the bases in Germany were Spangdahlem, Zweibrucken, Hahn, and Ramstein AFBs and Weisbaden Army Airfield. A total of 34 sample units were surveyed with a minimum of four at each installation. Twenty-four of these units were from the air bases in Germany. The sample units were selected randomly along the length of the runways. Generally, a sample was taken in the primary departure end, the center portion, and secondary departure end.

In addition to the PCI survey, a team of experienced engineers was assembled to rate each section surveyed.

The following procedure was performed for each sample unit:

1. The sample area was located and marked on the pavement surface.

2. Each rater was given a form (Figure 2) to provide an independent rating of the pavement's condition (pavement condition rating, PCR).

---

[1] *Airfield Pavement Evaluation Program*, Air Force Regulation 93-5 (Department of the Air Force [USAF], 18 May 1981).

[2] Shahin, M. Y., M. I. Darter, and S. D. Kohn, *Development of a Pavement Maintenance Management System, Volume I, Airfield Pavement Condition Rating*, AFCEC-TR-76-27 (USAF, November 1976); Shahin, M. Y., M. I. Darter, and S. D. Kohn, *Development of a Pavement Maintenance Management System, Volume II, Airfield Pavement Distress Identification Manual*, AFCEC-TR-76-27 (USAF, November 1976).

*1 in. = 25.4 mm, 1 ft = 0.30 m, 1 yd = 0.914 m.

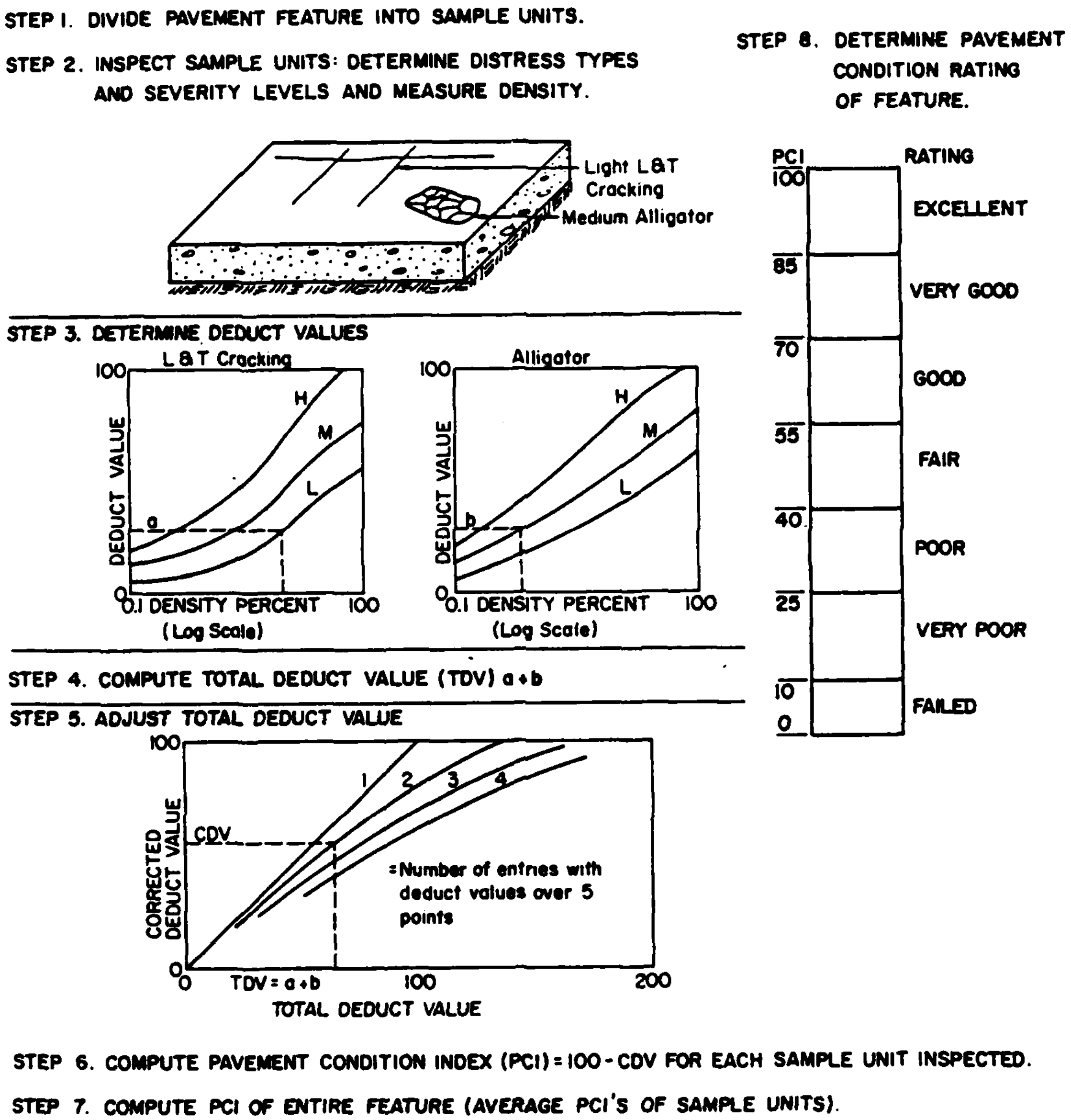

Figure 1. Steps for determining PCI of a pavement feature.

PAVEMENT CONDITION RATING

100	EXCEL
85	V.GOOD
70	GOOD
55	FAIR
40	POOR
25	V.POOR
10	FAILED

NAME ____________________
BASE ____________________
RATE ____________________
SECTION ____________________

1. PLS. RATE PAVEMENT SECTION (ie GOOD, FAIR, ETC.) ACCORDING TO SURFACE OPERATIONAL CONDITION AND STRUCTURAL INTEGRITY. ASSUME THE SAMPLE UNIT TO REPRESENT THE ENTIRE SECTION, AND THAT THE SECTION IS A PRIMARY PAVEMENT : ____________

2. GIVE A SCORE WITHIN ABOVE RATING : ________

3. LIST DISTRESSES (REASONS) FOR YOUR RATING

____
____
____
____
____

Figure 2. Pavement Condition Rating form.

3. A visual condition survey was performed, using the PCI method as specified in AFR 93-5.

The PCIs were not calculated until all the samples were rated, so that the raters would not be biased by the intermediate results.

Summary of Field Survey Data

The first condition surveys were performed at Hill and Tyndall Air Force Bases. Table 1 summarizes the PCR and PCI ratings; Figure 3 is a plot of the average PCR compared to the calculated PCI.

As shown in Figure 3, there is generally close agreement between PCR and PCI for these sample units, the largest differences being 10 points at Tyndall and 9 points at Hill. At Tyndall, the maximum difference occurred in a sample unit which contained a depression, some jet blast, medium reflection cracks, patching, and medium raveling. It appears that the raters may have overlooked some of the medium raveling, because the pavement surface was damp from rain. At Hill, the maximum difference was a sample unit in an area where there was some alligator cracking; a review of the rating forms indicated that the raters did not recognize the amount of alligator cracks present and subsequently gave higher values.

Table 2 and Figure 4 summarize the ratings for the bases surveyed in Germany. As shown in the table, the calculated PCI is generally lower than the average PCR. Also, five of the 24 samples showed differences of at

Table 1
Summary of Ratings for Bases Surveyed in United States

Airfield	Sample Number	Pavement Condition Rating R1	R2	R3	R4	R5	Avg PCR	Calculated PCI	PCI−PCR
Hill, UT	1	75	80	80	73	75	77	83	6
	2	60	70	70	64	70	67	58	9
	3	50	60	51	65	60	57	58	1
	4	54	50	70	60	50	57	52	5
	5	60	75	65	70	72	68	73	5
	6	80	85	75	75	83	80	84	4
Tyndall, FL	1	68	85	75	73	83	77	80	7
	2	70	73	70	70	72	71	61	10
	3	88	84	82	70	80	82	80	2
	4	78	74	75	70	73	74	76	2

AVG |PCI PCR| 5.1

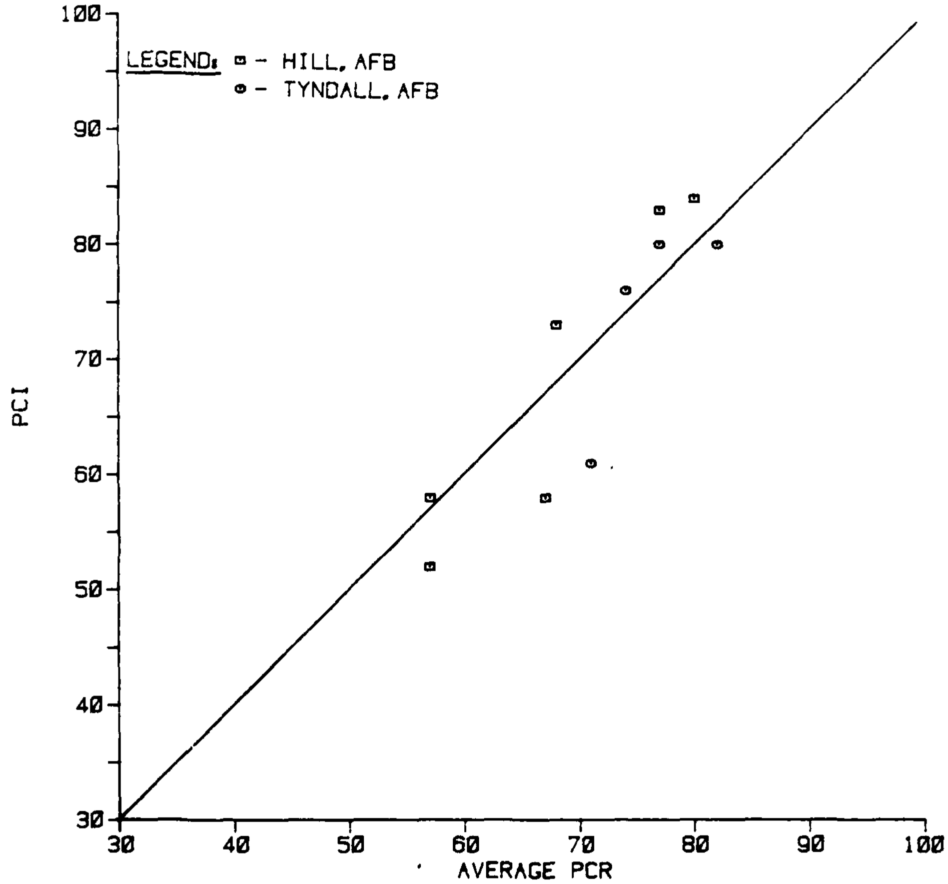

Figure 3. PCI vs. PCR for United States air bases.

Table 2
Summary of Ratings for Bases Surveyed in Germany

Airfield	Sample Number	Pavement Condition Rating R1	R2	R3	R4	Avg PCR	Calculated PCI	PCI–PCR
Spangdahlem	1	50	54	54	60	55	65	10
	2	55	80	85	65	71	77	6
	3	75	60	71	70	69	66	3
	1A	68	60	68		65	73	8
	2A	43	45	47		45	39	6
	3A	85	76	85		82	74	-8
	4A	85	81	88		85	74	11
Zweibrucken	1	83	68	72	85	77	68	-9
	2	81	75	67	75	75	69	-6
	3	85	90	70	80	81	75	-6
	4	85	90	67	85	82	78	-4
Hahn	1	80	72	80	90	81	77	4
	2	65	61	72	85	71	65	-6
	3	60	84	65	90	75	76	1
	4	84	80	82	75	80	77	3
	5	83	72	85	85	81	82	1
Ramstein	1	88	86	85	85	85	75	-10
	2	80	78	80	70	77	77	0
	3	75	68	65	55	66	63	-3
	4	69	71	75	85	75	78	3
Weisbaden	1	85	95	90	90	90	80	-10
	2	78	84	75	80	79	66	-13
	3	85	75	72	80	78	79	1
	4	75	75	71	80	75	75	0

AVG |PCI PCR| = 5.5

least 10 points. In reviewing these sample units, it appeared that the raters were generally underestimating the amount of medium raveling present. This distress was hard to measure in the field due to its erratic occurrence over relatively small areas of the sample. Also, the distress was being measured under a new definition for the severity levels, which had been established based on the first field survey.

To further analyze these findings, the distresses encountered in the field were summarized (see Table 3). The summary was calculated by placing all the sample units in one pavement section in the PAVER pavement management system.[3] Thus, the table represents a total of all distresses found at the bases. As shown in

Table 3
Summary of Distress Types From Bases in Germany

Distress Type	Severity	Percent Area
Bleeding	N/A	0.29
Long/Trans CR	High	0.00
Long/Trans CR	Low	0.24
Long/Trans CR	Medium	0.12
Oil Spillage	N/A	0.03
Patching	Low	1.48
Patching	Medium	0.94
Rutting	Low	0.16
Slippage CR	N/A	0.01
Weather/Ravel	High	0.00
Weather/Ravel	Low	59.66
Weather/Ravel	Medium	5.67

[3]M. Y. Shahin and T. D. James, *Development of a Pavement Maintenance Management System, Volume X: Summary of Development From 1974 Through 1983* ESL-TR-88-55 (Air Force Engineering and Services Center, June 1984).

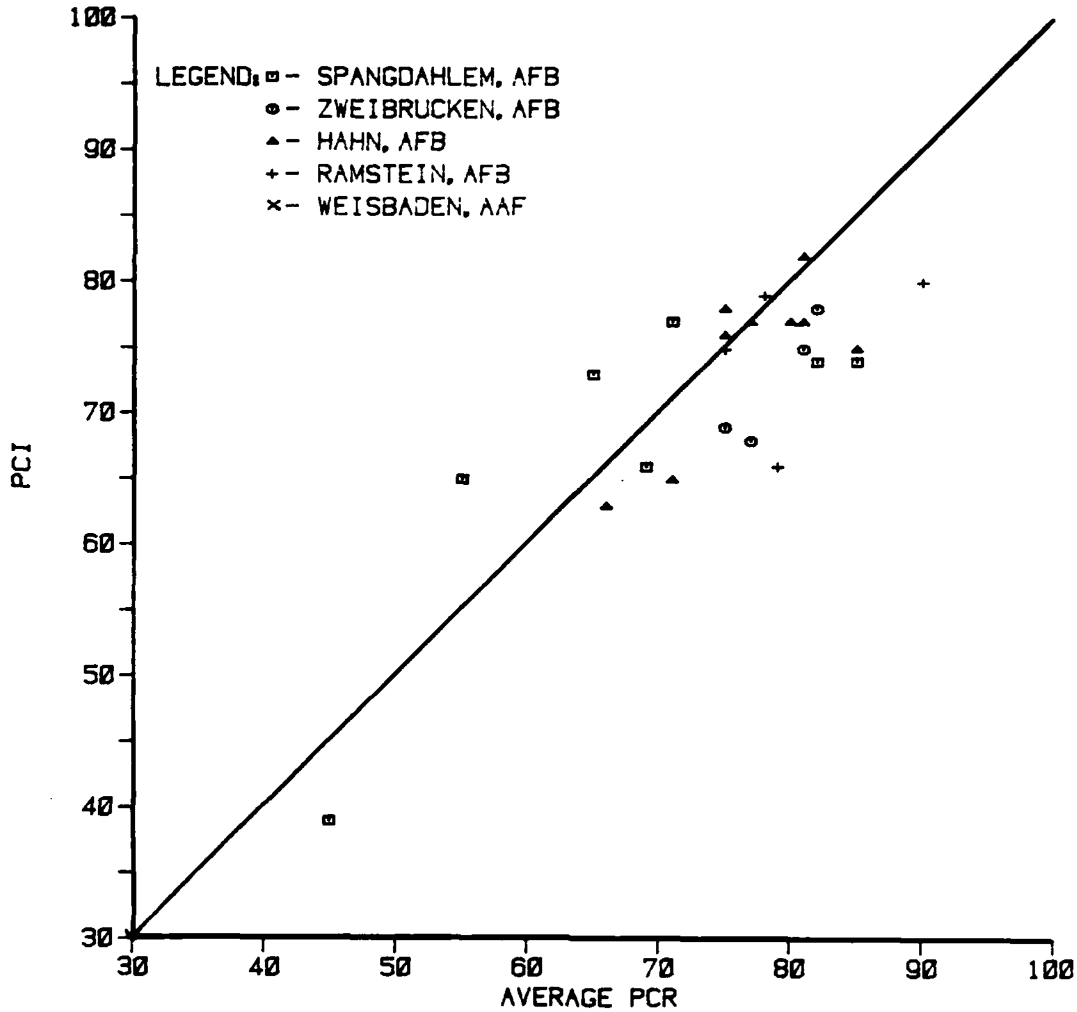

Figure 4. PCI vs. PCR for German air bases.

the table, the predominant distresses were raveling/weathering and patching.

Figure 5 compares the PCR and PCI values for the total data set. As shown, the average PCR correlates well with the calculated PCI. The average absolute difference of PCI and PCR (PCI − PCR) is 5.4 points for the entire data set. Figure 6 shows a distribution of the PCIs for the sample units. Most of the sample units are in the range of 55 to 85, indicating that the pavement is in good to very good condition. The overall average PCI of all sample units is 72.

Evaluation of Field Survey Data

The first condition survey was performed at Hill AFB. During the survey, many points about the differences between PFS and dense-graded asphalt concrete (DG) were evaluated. One initial concern was the damming effects of filled cracks and patches and their effect on the operational condition. There was very little patching at Hill; however, filled cracks were present. The engineers' ratings did not indicate that the filled cracks would have greater deduct values on the PFS. This is shown by the close agreement of PCI and PCR values. Another major point discussed at Hill

was the deterioration of underlying asphalt concrete material. In several areas, patches had been placed in locations where surface depressions had developed. The depressions were caused by the failure of the underlying asphalt concrete material. When excavated, the material was found to have lost all bond, and the asphalt had been stripped from the aggregate; however, very little surface distress had appeared before these areas developed. In some cases, slippage cracks did develop before failure. Thus, slippage cracks in PFS were considered indicative of deterioration in the underlying asphalt concrete. At Hill, only small slippage cracked areas were found; thus, not enough information was available to define severity levels for the distress.

The PFS at Tyndall is more correctly defined as a plant mixed seal coat. The material has very little internal drainage; the friction surface is provided by large aggregate pieces imbedded in an asphalt mastic. The ratings at Tyndall were very close to the calculated PCIs. However, one major difference was that the cracks in the surface were sometimes wider at the top and did not appear to continue through the dense

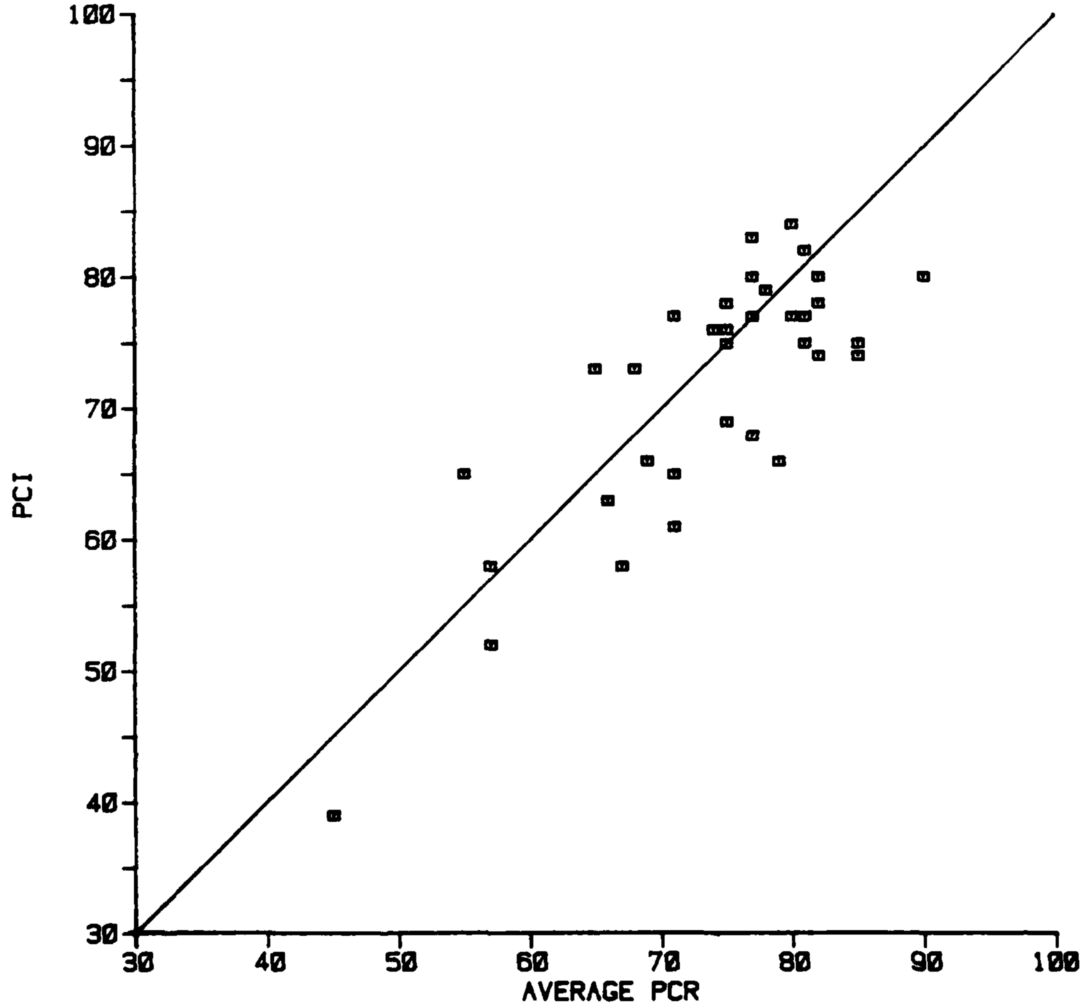

Figure 5. PCI vs. PCR for all bases surveyed.

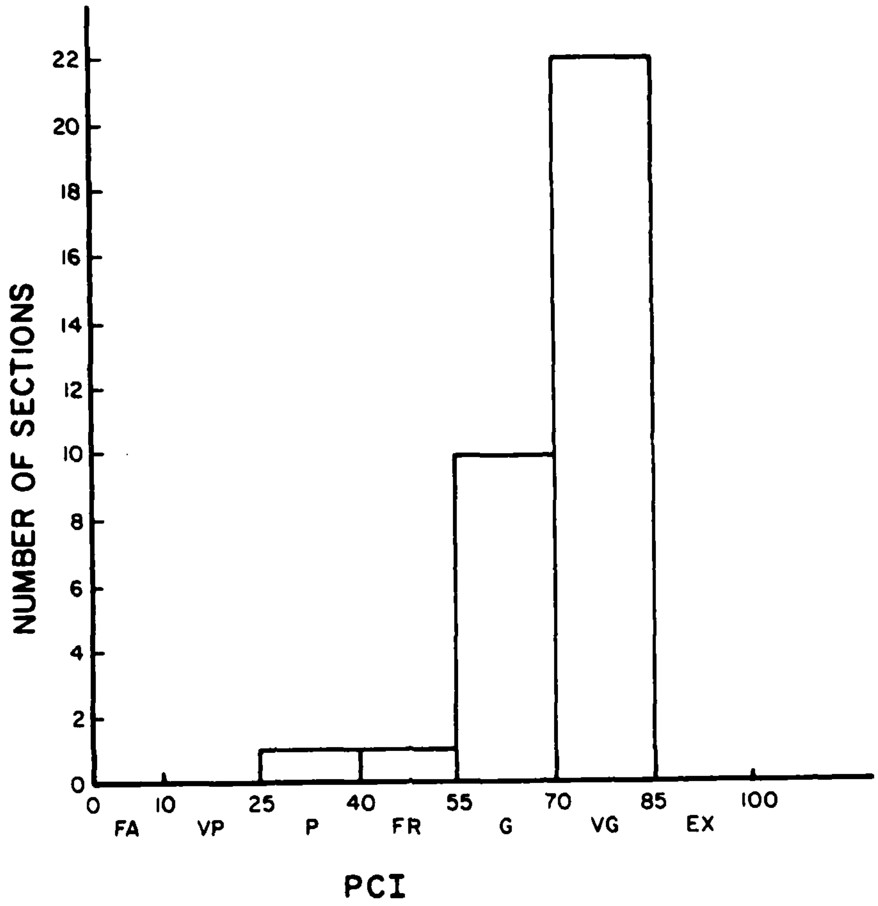

Figure 6. Distribution of sample unit PCIs.

asphalt concrete material. Based on this observation, a modification to the longitudinal and transverse crack severity definitions was suggested (see Figure 7).

The air bases in Germany were the last to have the condition survey performed. Before performing any ratings or PCI surveys, Ramstein AFB was inspected to view the general condition of the PFS material. The first difference noted was that there was more raveling on the surface of PFS material in Germany than had been observed on the U.S. installations. Therefore, the severity-level definitions were modified (see Figure 8) before performing the PCI surveys. These new definitions were used in the survey to identify the raveled areas; however, the PCI was calculated using the original deduct value curves. A review of the PCR-PCI comparison indicates that modifying the severity-level definitions was sufficient and that the deduct curves do not need alteration.

As shown in Table 3, raveling/weathering was the predominant distress type found on pavements at the German bases. The large amount of patching shown is from the two sample units at Spangdahlem AFB.

The effect of dense-graded patches in PFS was also thought to be one area of difference between PFS and dense-graded asphalt concrete. The use of dense-graded asphalt concrete causes a damming effect at the patch which contributes to differential skid resistance of the surface. The patches at Spangdahlem were dense-graded; however, the surface condition of the patches

These severity levels are in addition to the existing *definitions*:

Severity Levels:

- L – Average raveled area around the crack is less than 1/4 in. wide (Figure 7a).
- M – Average raveled area around the crack is 1/4 to 1 in. wide (Figure 7b).
- H – Average raveled area around the crack is greater than 1 in wide (Figure 7c).

Figure 7. Additional severity-level definitions for cracking in PFS pavements.

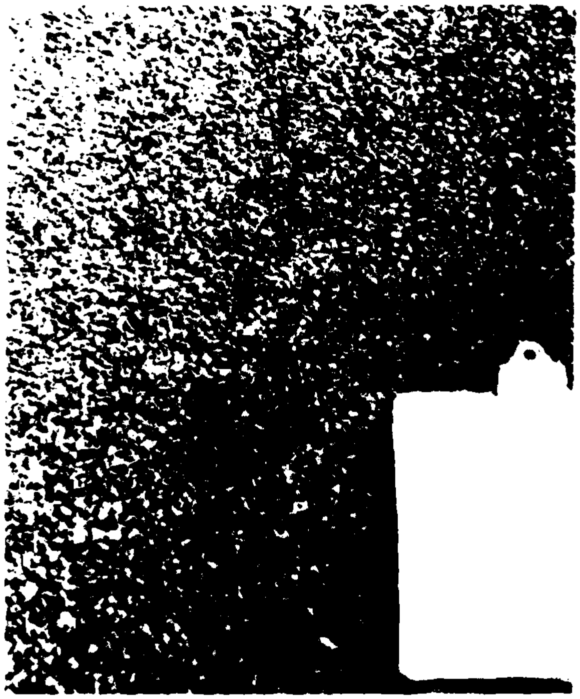

Figure 7b. Medium-severity crack in PFS pavement. Average raveled area around the crack is 1/4 to 1 in. wide.

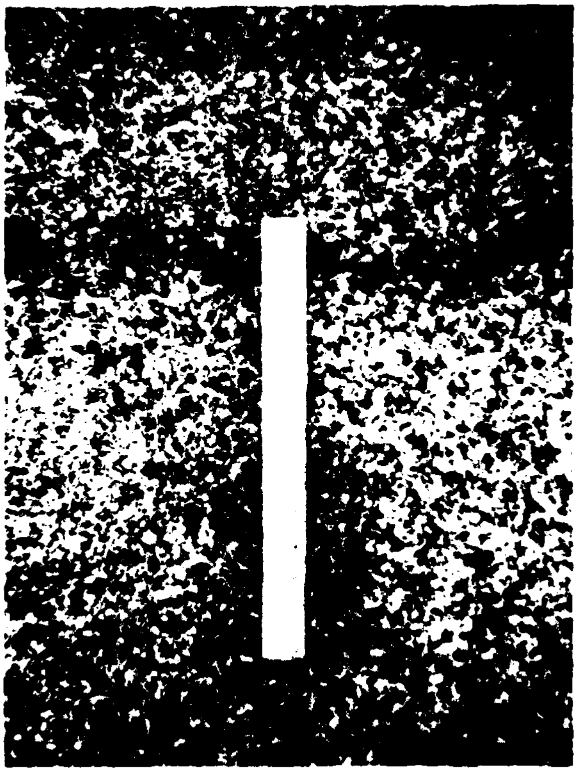

Figure 7a. Low-severity crack in PFS pavement: Average raveled area around the crack is less than 1/4 in. wide.

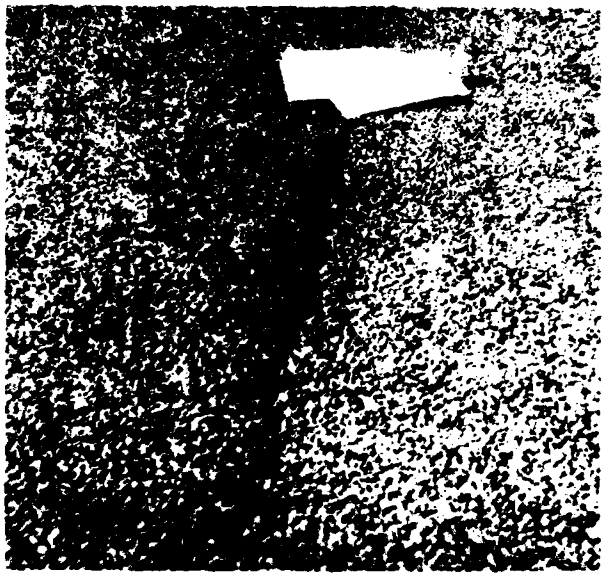

Figure 7c. High-severity crack in PFS pavement. Average raveled area around the crack is greater than 1 in. wide.

NAME OF DISTRESS:

RAVELING AND WEATHERING OF POROUS FRICTION SURFACES

Description:

Raveling and weathering are the wearing away of the pavement surface caused by dislodging of aggregate particles and loss of binder. They can be caused by traffic wear and/or blast from jet engines. (Areas are aggravated by blast; they are not subject to burning as caused by direct jet blast.)

The surface texture of porous friction surfacing is naturally rough due to its open graded nature. Figures 8a and 8b are pictures of typical porous friction material where raveling and weathering have not developed.

Severity Levels:

L Most of the fine aggregate (passing the #4 sieve, i.e., less than 1/4 in.) have been lost and only a few of the larger pieces have been dislodged, causing little or no FOD potential (Figure 8c).

M Fine aggregate is missing, and many of the larger pieces are dislodged. The surface is rough and pitted, but average depth of erosion is less than 1/4 in. Some foreign object damage (FOD) potential is present (Figures 8d and 8e).

H - Surface texture is very rough and pitted. Erosion of aggregate pieces exceeds 1/4 in. in depth, and definite FOD potential exists (Figure 8f).

How to Measure:

Raveling and weathering is measured in square feet of surface area. Mechanical damage caused by hook drags, tire rims, or snow plows are counted as areas of high-severity raveling and weathering.

Figure 8. Modified definition of raveling and weathering.

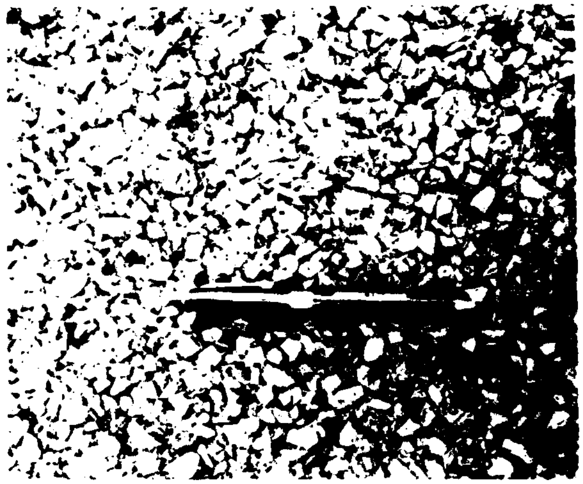

Figure 8a. Example 1 of a typical PFS surface with no raveling and weathering.

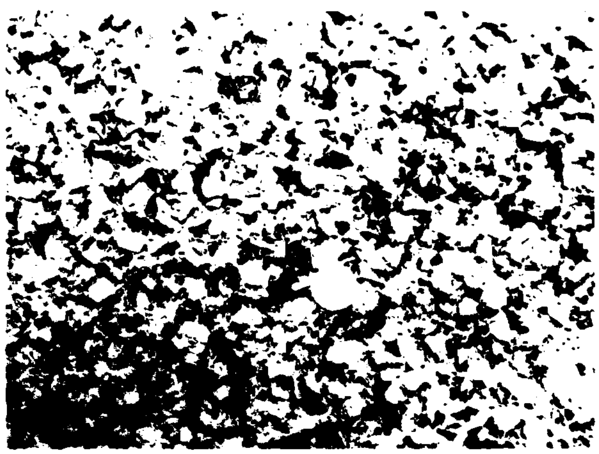

Figure 8b. Example 2 of a typical PFS surface with no raveling and weathering.

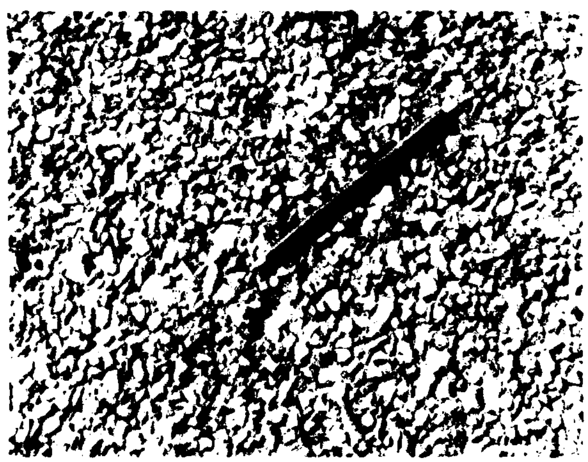

Figure 8c. Low-severity raveling/weathering in PFS pavement.

Figure 8d. Medium-severity raveling/weathering in PFS pavement.

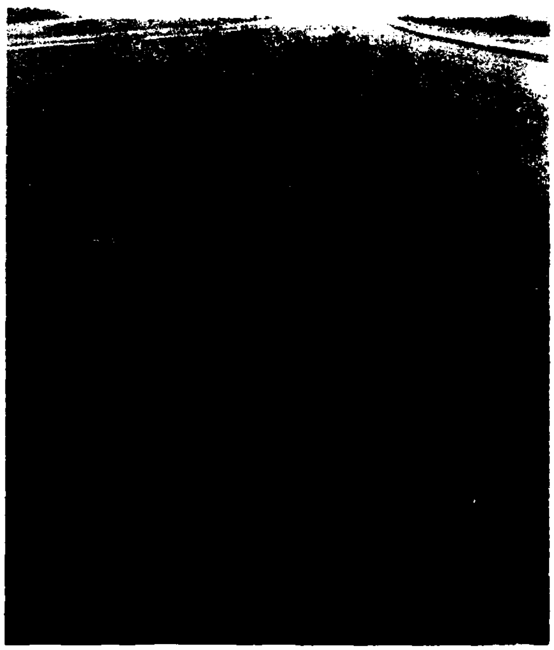

Figure 8e. Medium-severity raveling/weathering showing rough and pitted surface.

Figure 8f. High-severity raveling and weathering in PFS pavement.

was very poor, and the edges of the patches were cracking, which caused them to be rated as medium-severity. The ratings and PCIs for these sample units do not differ significantly. However, the survey team recommended that dense-graded patches be rated as medium-severity due to the differential friction problem. Although no samples with this condition were surveyed, this appears to be a reasonable assumption.

Another major concern at the USAFE bases was the occurrence of delaminated areas. These are areas where the thin PFS material comes unbonded from the dense-graded asphalt concrete leveling course. In many cases, these areas are easily dislodged by the blast from jet engines. Recently, a "hammer survey" was performed at Hahn and Spangdahlem AFBs to locate these areas. The survey was performed using ball-peen hammers to sound the pavement surface; a "hollow" sound is encountered in the delaminated areas. The results of the "hammer" surveys indicated large areas of delamination. A recent AFESC evaluation has supported this survey. However, no surface distresses were found to indicate this phenomenon except for a few small areas of very light slippage cracks. These areas were not located in places where the hammer survey had indicated large delaminations.

3 RECOMMENDATIONS

The following recommendations were based on the results of the field investigation:

1. The modified severity-level definitions shown in Figures 7 and 8 should be incorporated into AFR 93-5 for use on PFS pavements for longitudinal/transverse cracks and raveling/weathering, respectively.

2. Low severity dense-graded patches in PFS should be rated as medium-severity.

3. Because PFS is permeable, raveling/weathering is a common distress. However, the PFS can lose its permeability over time. Therefore, it is recommended that if the permeability loss is more than half the original amount, a surface treatment of asphaltic material to prevent further raveling should be considered. This surface treatment would hold the aggregate pieces in the system without destroying the coarse surface texture of the PFS material. *Thus, permeability should be monitored from the time of construction.* This topic should be addressed in the new *Maintenance of Surfaced Areas*[4] manual.

4. Delamination of the PFS material from the underlying dense-graded asphalt was noted as a major problem, but no surface distress was uniquely identified with it. It is therefore very difficult to account for using the PCI method. Thus, since failure of the asphaltic concrete will require considerable maintenance to keep the airfield active, a nondestructive test should be developed to locate these areas, possibly using ground-penetrating radar and thermographic methods. (Note: The survey team felt that the "hammer survey" method was nonconclusive.)

5. There are several areas in which there is a lack of knowledge about the field performance of PFS pavements. The following are examples:

a. Underlying layers of dense-graded asphalt concrete have been found to deteriorate, causing rapid failures of the PFS surface.

b. The effect of damming at filled cracks or patches on performance is not known.

c. The effects of depressions on the PFS raveling are not known.

Therefore, the PCI should be monitored carefully on older PFS pavements; when possible, surface conditions should be documented when such failures occur.

6. All available PCI and construction date information should be collected for PFS pavements, and a PCI Time Chart developed for this type of pavement. Based on this study, it appears that PFS pavements may follow a different trend than conventional asphaltic concrete pavements. This information will therefore help in planning maintenance activities for these pavements.

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